transaction, some pieces of information which are not required or are not necessary for a transaction might be required or leaked without notice.

Information privacy broker: a service which checks and restricts the usages of service information based on a necessary-only policy may play the broker.

Solution: $(IP|_{CS} \rightarrow (check(access)|_{iSVB}\ AND\ validate(necessary)|_{iSVB}))$

3.4 Classification of SVB from knowledge management perspective The Classification of SVB is a prerequisite for avoiding

the cost of reinvent of existing SVB and select the most appropriate ones for specific usage. It is also required for identifying new opportunities of creating new SVB. However this is also a big challenge since it involves knowledge from multiple domains crossing various abstraction layers. The modeling and expression of organization may be very complicated and crosscut multiple interrelated conceptual dimensions/perspectives. In Figure 4 we demonstrate our work towards organizing empirically collected SVB from a knowledge manage perspective. The problem solving framework is composed of three top level categories. At the category of *Problem solving*, *problem* to *solution* is bridged by *Knowledge broker*. knowledge broker consists the category *Resource* and the category *Implementation*. Some previous described SVBs are classified by relating to the items of the categories, such as:

i. Inside the category *Resource*, *information* is bridged by *translation broker* and proxy brokers such as *reputation broker*, *location broker*, *IP broker*, etc.; *data* is bridged by *format broker*; *operation* is refined as *control* and *execution* which are bridged or optimized by brokers such as *security broker*, *privacy broker*, *available time broker*, *latency broker* and *throughput broker*, etc. It mentions that *data* might also require *security broker* and *privacy broker* according to data contract [35]. It differs from the *security broker* and *privacy broker* for operation in the E-Service contract.

ii. The category *Implementation* is modeled as from *description* to *implementation*. The involved activities can be abstracted as *decomposition* and *integration* which can be optimized by DSVBs of *composition broker* and *federation broker*, etc.

From the domain of E-Tourism, we have identified many application areas which can be implemented with SVB in different categories[14] which is shown in Figure 5.

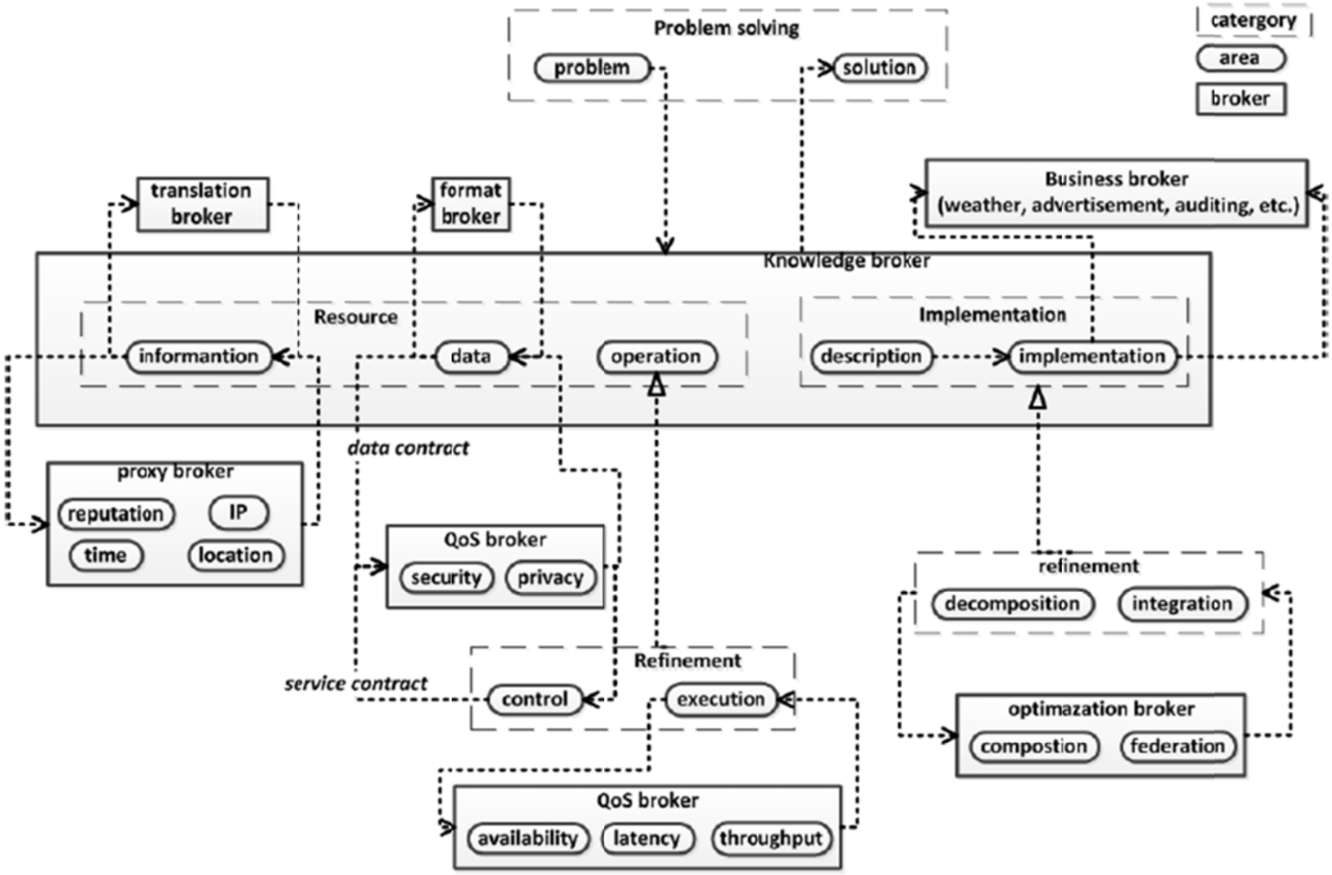

Figure. 4. Classification of SVB from the perspective of knowledge management

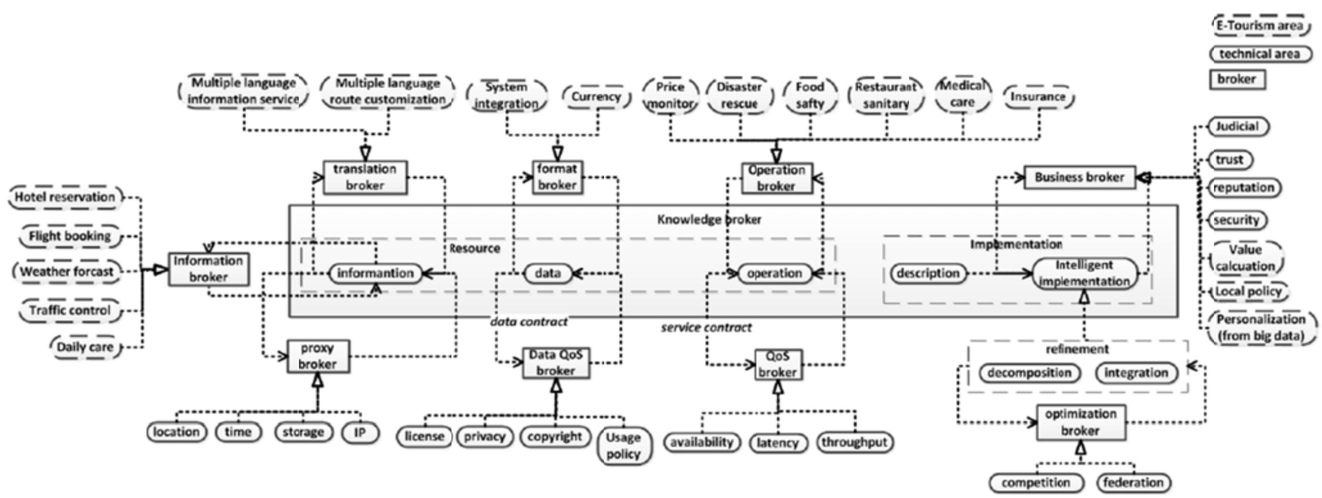

Figure. 5. Empirical SVB classification from an E-tourism background

4. Two-Level E-Contract Based Implementation Framework

In the service ecosystem, due to the interface of the services and their correlation history, the services in the ecosystem will form the composable relation between each other which means that the two services can be used to form a composition to offer added-value for the consumers. As the number of services available for consumers is increasing rapidly, there are many services which offer the similar functionality. For examples,all of ”Google Map”, ”Baidu Map”, ”Yahoo Map” and ”Facebook Map” provide the map related services. These services with the similar functionality will form a specific domain. The service in the same domain can somehow replace each other with some adapters [34]. Furthermore, the providers will publish services into the ecosystem so that the consumers can use the services to fulfill their requirement. Some providers such as Google, Yahoo and Amazon will offer different services in different domains so that they may offer the complete solution for the consumers. Some others will provide a few specific services in the specific domain. Taking Twilio as an example, it focuses on telephony and only offers the Twilio service in the telephony domain for the consumers. As different providers perform well in different domain, the providers will assign the contract with the others to form a vertical alliance or horizontal alliance to guarantee their core competencies [20]: the providers who provide similar services may assign contracts with each other so that they can get the replace services to increase the fault-tolerance for the consumers; the providers who provide the composable services may assign contracts with each other that they can increase the Qos for the whole composition.

Thus we can get a two-level service contract framework in the service ecosystem which consists of two networks: the service composable network is a directed network in which each node refers to a service and each edge refers to the composability between two services, the direction of the edge refers that the output of the source service can be the input or part of the input for the target service. The provider contract network is an undirected network in which each node refers to a provider and each edge refers to the service contract assigned by two providers.

Fig. 6 demonstrates a two-level service contract network framework for the service ecosystem which consists two networks: the service composable network which refers to the composablity among services, and the provider contract network which refers to the contract relation among providers.

Example: For the illustration shown in Fig. 6 , providers Pa, Pb, Pc, Pd, Pe form the provider contract network based on their contract with each other. Provider Pa offers service S1 and S2, Provider Pb offers services S3, S4 and S5, etc. Service s1, s2, s3, s4, s5, s6, s7, s8 and s9 construct the service composable network and S1, s3, and s6 are similar in the functionality that they form a specific domain.

5. The Case for the Service Contract Broker

5.1 Service Contract Broker for Service Selection

The requirement of the consumer is becoming more complex. Sometime single services cannot fulfill the requirement that they need to select some services to form compositions. If the services are provided by different providers, the providers with a contract can help to guarantee the reputation of the composition. For example, Pd and Pc have a contract while it is not for Pd and Pb, the composition for s6 and s7 will gain a higher reputation than s6 and s5. In this case, the service contract broker will suggest services with higher reputation for the consumers. Even if the services are provided by the same provider, sometimes the QoS cannot meet the consumers' requirement. For example, s1 and s2 can fulfill the consumer's functionality requirement while

the price is too high for the consumer. In this case, the service contract broker will help to find the services which are offered by the provider's contractors and then use the service to replace the similar service to fix the mismatch for the consumers. For example, suppose that s3 is much cheaper than s1 and then the broker will use s3 to replace s1 and offer s3 and s2 for the consumers.

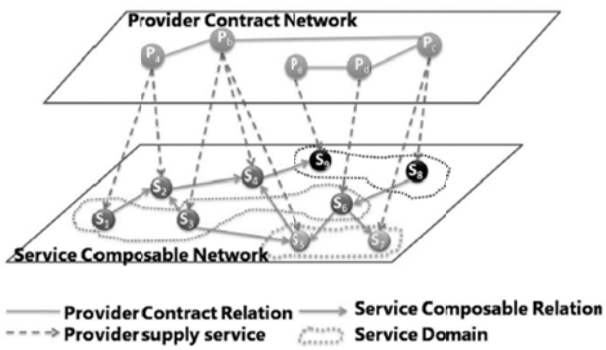

Figure. 6. Two-level service contract network framework

5.2 Service Contract Broker for Service Emerging

For the providers with a strong contract, if the services they offer are not composable, the providers will intend to build an adapter among their services so that their alliance can gain higher competitiveness in the ecosystem. For example, Pb offers service s4 which can be composed with s9 provided by Pe and there is no contract between these two providers. Also Pc offers service s8 which has a similar functionality as s9, however there is huge mismatch between s4 and s8. As Pb and Pc builds a strong contract relation with each other, they may modify the interface of their services to make them composable or create a new service together to bridge their services. In this case, the service contract broker will offer the suggestion for new services. Thus the service contract broker can promote the growth of the service ecosystem.

6. Simulating *SVB*

In order to simulate *SVB* patterns and their effect on customer value, we make use of the scenario provided in Fig. 7. While *Customer 1* accesses the sequence of services directly, *Customer 2* makes use of *SVB* brokers to aid in his response. This may come from multiple domains of values.

This scenario is simulated using Monte-Carlo simulations in MATLAB with distributions representing various domains of functional, QoS and business value aspects studied in Section II. Values such as *response time* and *availability* are modeled as heavy tailed distributions [21]. *Request amount* and *Network Traffic* are modeled with exponential distributions; *Price*, *License Values* and *Security Levels* are drawn from uniform distributions. Note that some brokers such as *Location* and *Reputation Limit* would require a real-world implementation over actual services and are exempted from this analysis. Such a probabilistic model for value is consistent with perspectives of function/QoS/business [21], [23].

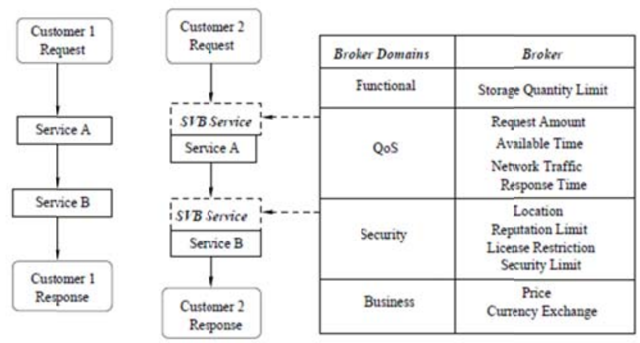

Figure. 7. Scenario comparing two customers.

As observed in Fig. 8, the inclusion of an *SVB* broker improves multiple domains. The response time distribution and network traffic show *lower* values for customer 2. This is traded off with the necessity to pay higher cost values that can provide better security and license values. Though this is a representative example, it can be envisioned as being applicable to real world applications. The service broker can provide access to valuable upgrades in multiple domains that should be encouraged.

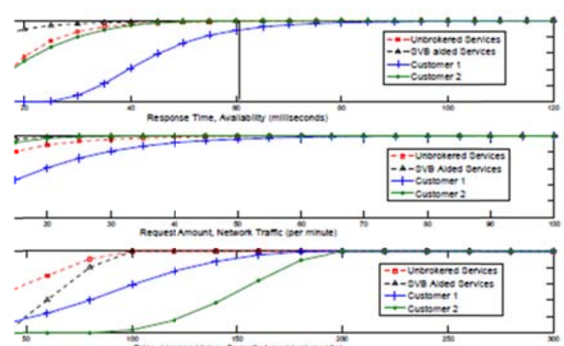

Figure. 8. Monte-Carlo runs of two customers' output behaviors.

From a *business* perspective, the improved performance due to the introduction of a broker could provide better contractual agreements to a composition of these services. In spite of higher costing services, the tradeoffs can be improved in multiple contractual domains of QoS, security and composition efficiency. Aspects provided by the DSVB such as testing and advertisement provide further impetus to the adoption of brokers for business based services.

7. Related Work

Bichler et al.[1] promote to use brokers to enhance the application level interpretability of electronic commerce. Yu and Lin[39]utilize service brokers to meet SLAs of services and construct trust network for bridging reputation information[25]. It does not directly support the construction of $\mathbb{D}_B$ and $\mathbb{D}_V$ oriented solutions. Srikumar et al.[36] use a broker to enable grid resource searching and distribution where a broker functions mostly as an autonomous agent[30]. D'Mello et al.[7] use a broker to select qualified services in terms of QoS of SLA for service composition. Loreto et al.[26] use brokers to integrate telephone business and IT world in the manner of a intermediate layer. Most of existing broker researches[28], [24], [31], [4], [27], [17] focus on using brokers to discover, match,negotiate, select and compose services with best QoS in a service composition from either a technological perspective or a business perspective. Rosenberg and Dustdar[33] use brokers to bridge the difference of heterogenous business rules. Budgen et al.[2] introduce an information broker to integrate health knowledge and data with enhanced privacy protection. Based on service contracts, SVB covers more issues than SLA. SVB relates services not limited to technological level as most SLAs based approaches[39] have done but also to business level[1], [33], [3]. Cardellini et al.[3] use brokers to realize a global cost optimization based on probabilities. By integrating business services and technology services with value modeling, SVB identifies a bigger diagram where it can be applied positively.

8. Conclusion and Future Work

Service value broker (SVB) is a critical element for constructing a coming era of E-Service Economics since it coherently supports IT implementation of service system and integration of business strategies under the analysis of economical goals. The study of SVB by itself will open a lot of research directions:

i. **Conceptual level**: the introduction of SVB will bring changes to existing architecture of service system;
ii. **Solution extension:** existing solutions can be extended to this concept such as reuse on SVB level and reuse [11] solutions covering SVB;
iii. **Implementation level**:SVB will bring influence directly to the service contract description and contract interface design;
iv. **Formal abstraction**: SVB will be a new target for formal modeling, verification and checking on properties such as equivalence, deadlock[5] and crash situations, etc.

In this paper we present the work towards enumerating useful SVBs which can be reused directly by stakeholders. We would like to explore higher level SVB or DSVB which might be in the form of semantics brokers with contextual information such as temporal constraint [6], reputation network [38] and service evolution [32], etc. Like a blade with two edges, the usages of SVB could introduce new challenges such as fraud SVB, loose controllability due to indirectly control, shattered responsibilities, etc. We are interested in exploring the dimension of avoiding the negative usages of SVB through restricting the possibilities of unexpected subcontract relationships, monitoring the chained behavior and identifying the responsibilities, etc. We would like to see a deepening influence brought by SVB to the era of E-Service Economics[15].

Acknowledgment

This paper was supported in part by CNSF grant 61162010 and 61363007 and by HNU Research program grant KYQD1242 and HDSF201310 . * stands for corresponding author. We thank Prof. Zibin Zheng for precious advice.

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